

## A Novel Technique for Intracorporeal End-to-End Anastomosis in Totally Laparoscopic Colectomy: A Preliminary Single-Center Experience

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## Abstract

**Background:** Recently, several studies have demonstrated the feasibility and effectiveness of totally laparoscopic colectomy with intracorporeal anastomosis. In this study, we describe our novel technique for intracorporeal end-to-end anastomosis, which we have named the modified book-binding technique (MBBT), in totally laparoscopic colectomy, and present our preliminary experience in clinical practice.

**Patients and Methods:** MBBT is performed as follows: (1) the 45-mm endoscopic linear stapler is inserted parallel into each hole at the mesenteric side of the proximal and distal ends of the bowel; (2) before stapling, the ends of the bowel are repositioned such that the oral side of the stapler tip is pushed toward the oral bowel, and the anal side is pushed toward the anal bowel, with the root side of the stapler remaining as a pivot point. Then, the stapler is inserted deeply; (3) the anterior wall of the bowel is excised according to ischemia; (4) the anterior wall of the bowel is stapled again in 2 parts using the 60-mm endoscopic linear stapler.

**Results:** A total of 7 patients underwent totally laparoscopic colectomy using this technique. One patient experienced postoperative ileus. There were no other postoperative complications, including anastomotic leakage or intraperitoneal abscess. All patients have survived without any recurrence or late-phase complications.

**Conclusion:** This novel technique has a feasibility for end-to-end anastomosis in totally laparoscopic colectomy, ensuring a sufficient anastomotic area. MBBT could be an alternative method of intracorporeal anastomosis.

## Article Highlights:

- We introduce our novel technique for intracorporeal end-to-end anastomosis, which we have named the modified book-binding technique (MBBT), in totally laparoscopic colectomy.
- This novel technique has a feasibility for end-to-end anastomosis in totally laparoscopic colectomy, ensuring a sufficient anastomotic area. MBBT could be an alternative method of intracorporeal anastomosis compared with FEEA and overlap.

## Keywords

Laparoscopic Colectomy; Intracorporeal Anastomosis; End-to-end Anastomosis

## Abbreviations:

LAC-EA: laparoscopy-Assisted Colectomy with Extracorporeal Anastomosis  
TLC-IA: Totally Laparoscopic Colectomy with Intracorporeal Anastomosis  
FEEA: Functional End-to-End Anastomosis  
MBBT: Modified Book-Binding Technique

## Background

Laparoscopic colectomy as a minimally invasive surgery has gained wide acceptance because of its feasibility and lower rates of complications and morbidity compared with open colectomy [1-3]. In addition, several studies have demonstrated comparable oncologic outcomes between laparoscopic and open approaches against colon cancer [4-6]. In most countries, when a laparoscopic approach for colectomy is decided, surgeons often select laparoscopy-assisted colectomy with extracorporeal anastomosis (LAC-EA) as the standard procedure.

Recently, several studies have demonstrated the feasibility and effectiveness of totally laparoscopic colectomy with intracorporeal anastomosis (TLC-IA) [7-9]. Possible

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advantages in TLC-IA compared with LAC-EA are as follows;

1. Good visualization demonstrated by a similar anastomotic leak rate;
2. Less traction on the mesentery with a decreased rate of prolonged postoperative ileus;
3. Smaller incision with less postoperative pain;
4. Possibility of performing a suprapubic incision in all cases with less postoperative pain, decreased rate of pulmonary complications and incisional hernias, especially in obese patients. In fact, several systematic reviews and meta-analyses have demonstrated the usefulness of TLC-IA compared with LAC-EA in terms of perioperative morbidity, length of hospital stay, and surgical site infection, showing comparable incidences of anastomotic leakage and intra-abdominal abscess [7,9].

There are 2 well-known techniques for intracorporeal anastomosis in TLC-IA: functional end-to-end anastomosis (FEEA) and overlap anastomosis [10-12]. Both are truly side-to-side anastomosis, and these rarely cause abnormal dilation around the anastomotic lesion, such as blind loop syndrome, due to incising the circular muscle of the bowel [13-15]. On the other hand, end-to-end anastomosis is typically preferred from the point of view of less mobilization and not cutting a circular muscle of the colon. Ikeda and Oki reported a technique for end-to-end anastomosis between the remnant stomach and duodenum in totally laparoscopic distal gastrectomy, which they named the "book-binding technique" [16,17]. Although we applied this technique to colonic anastomosis in experimental animals, we were afraid of the area of anastomosis. Therefore, we have modified this technique to ensure a sufficient anastomotic area.

In this study we describe our novel technique for intracorporeal end-to-end anastomosis, which we have named the modified book-binding technique (MBBT), in totally laparoscopic colectomy, and present our preliminary experience in clinical practice.

## Patients and Methods

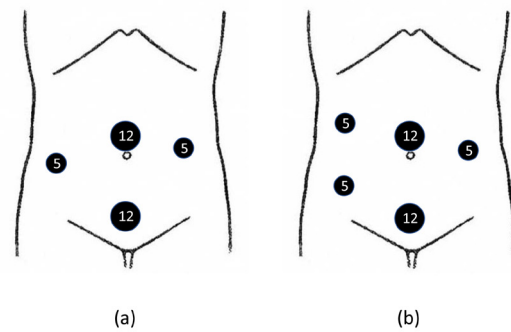
### Patients

From September 2013 to April 2014, 7 selected patients underwent TLC-IA using MBBT for adenocarcinoma. All patients provided informed consent and joined voluntarily. The patients, who had large tumor (>6cm in diameter), past history of abdominal surgery, and no sign of obstruction due to the tumor, were excluded.

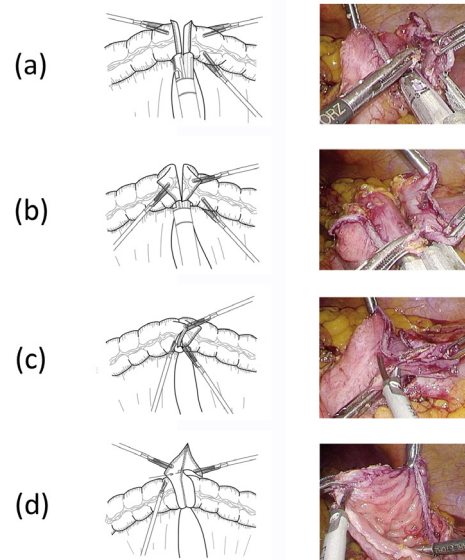
### Surgical technique of MBBT in TLC-IA

The procedure until specimen extraction in TLC-IA is the same as that in LAC-EA. The first port is placed, and pneumoperitoneum is established. Three or 4 other ports are placed at appropriate sites (Figure 1). Roots of main vascular pedicles are identified and divided according to extent of lymph node dissection. Mobilizing and dividing the mesentery, marginal and straight vessels are divided intracorporeally. Proximal and distal margins of the specimen are divided using an endoscopic linear stapler. Then, in TLC-IA, the specimen is inserted into a plastic bag and extracted through a small transverse suprapubic (Pfannenstiel) incision.

Before anastomosis, the oral and anal bowels are tentatively overlapped to confirm whether anastomosis is achieved without tension. First, the 45-mm or 60-mm endoscopic linear stapler is inserted parallel into each hole at the mesenteric side of the proximal and distal ends of the bowel (Figure 2a). Second, each end of the bowel is repositioned such that the oral side of the stapler tip is pushed toward the oral bowel, and the anal side is pushed toward the anal bowel, with the root side of the stapler remaining as a pivot point (Figure 2b). Third, the anterior wall of the bowel is excised (Figure 2c). Since it is easy to identify the ischemic area, this area is excised adequately, thereby preserving several millimeters of anterior staple line from the tip (Figure 2d). Fourth, the anterior wall of the bowel is stapled again in 2 parts using the 60-mm endoscopic linear stapler (Figure 3a-c). In the second part, the 60-mm endoscopic linear stapler or hand-sewn sutures are selected according to the



**Figure 1:** Illustration of typical ports placement for right-side colon cancer (a), and left-side colon cancer (b).



**Figure 2:** Illustration of first-half step of the modified book-binding technique.

(a) The 45-mm endoscopic linear stapler is inserted parallel into the enterotomy, which was created at the mesenteric side of the bowel.

(b) Each end of the bowel is repositioned to create a double-door opening, with the root side of the stapler remaining as a pivot point. This procedure enables insertion of the stapler up to the root of its cartridge.

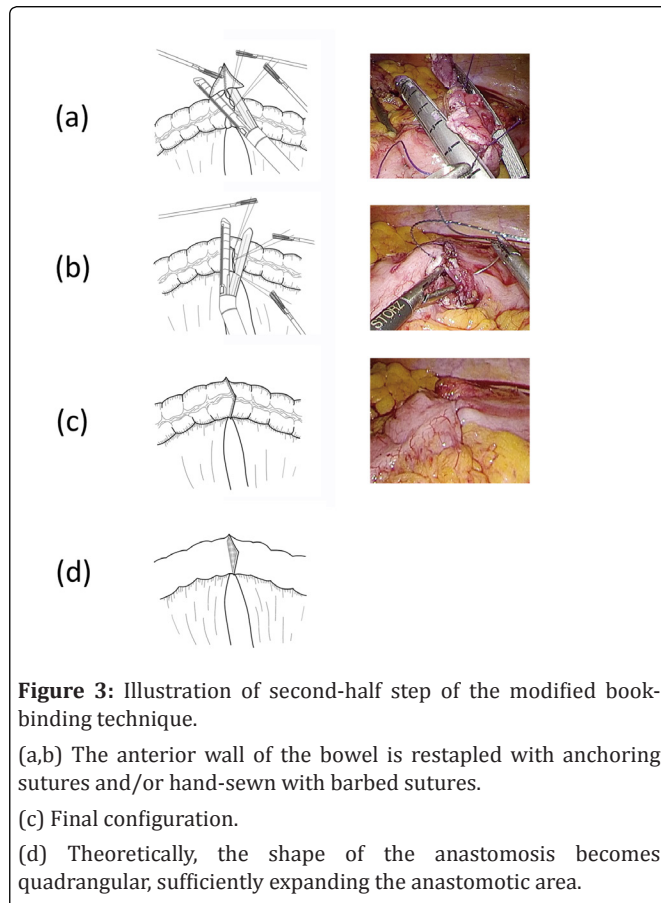
(c,d) The anterior wall of each bowel is excised. The area to be excised is well visualized.

surgeon's preference. Theoretically, the shape of the anastomosis becomes quadrangular, sufficiently expanding the anastomotic area [Figure 3d]. In this study, all these procedures were performed by a single surgeon (EH)

Postoperative wounds of this surgery are shown in (Figure 4).

## Results

The patient characteristics and surgical outcomes are shown in (Table 1). Seven men and 1 woman underwent TLC-IA using MBBT. Mean age was 73.6 years (range, 64-90 years), and mean body mass



index was 22.3 kg/m<sup>2</sup> (range, 16.8-26.0 kg/m<sup>2</sup>). Tumor locations were as follows: 4 in the transverse colon, and 1 in the cecum, descending colon, and sigmoid colon, respectively. The following operations were performed: one ileocecectomy, 1 sigmoidectomy, 2 transversectomies, and 3 left colectomies. Mean operating time was 286 min (range, 245-340 min), and mean estimated blood loss was 20.7 mL (range, 5-50 mL). There was no conversion to laparoscopy-assisted or open surgery, and no intraoperative complications were observed. One patient experienced postoperative ileus, which did not require bowel drainage. There were no other postoperative

complications, including anastomotic leakage or intraperitoneal abscess. Mean length of hospital stay was 16.3 days (range, 10-36 days).

Oncologic results are shown in (Table 2). Mean tumor size was 3.6 cm (range, 0.9-5.8 cm), and mean length of resected specimen was 24.1 cm (range, 17-31 cm). Mean number of retrieved lymph nodes was 14.9 (range, 7-25). TNM classifications according to the Union for International Cancer Control, 8th edition, were as follows: 5stage A and 2stage.

## Discussion

TLC-IA has gained widespread acceptance because of its high feasibility and low rate of postoperative complications [7-9]. However, to our knowledge, the methods of intracorporeal anastomosis in TLC-IA are side-to-side techniques, such as FEEA and overlap, and no study has described intracorporeal end-to-end anastomosis. In the present study, we demonstrated that our novel technique, which we have named MBBT, is a safe and feasible alternative in TLC-IA.

The book-binding technique was originally reported for end-to-end anastomosis between the remnant stomach and duodenum in totally laparoscopic distal gastrectomy [16,17]. The steps of this technique are as follows: First, the posterior intestinal wall is stapled. Next, the anterior intestinal wall is excised because the area surrounding the staples becomes ischemic. Then, the anterior intestinal wall is stapled again. We applied this technique to colonic anastomosis in an experimental animal model. However, the 45 mm endoscopic linear stapler could not be inserted up to the root of its cartridge. Then, the shape of the completed anastomosis looked slightly narrow, and we were concerned about an insufficient anastomotic area. Therefore, we decided that before stapling, both tip sides are repositioned like a double-door opening, with the root side remaining as a pivot point. This modification enables insertion of the stapler up to the root of its cartridge. Moreover, when excising the anterior intestinal wall, several millimeters of anterior staple line from the tip are preserved. Thus, the shape of the anastomosis becomes quadrangular, ensuring a sufficient anastomotic area. After we experienced this procedure several times on an experimental animal model, we applied to the patients who were diagnosed colon cancer.

Side-to-side anastomosis can cause abnormal dilation around the anastomotic lesion, such as blind loop syndrome, due to incising the circular muscle of the bowel [13-15]. This issue is less worrisome in end-to-end anastomosis. However, it is unclear whether this procedure leads to significantly less invasion than side-to-side anastomosis in terms of surgical stress response, and makes a significant clinical difference compared with side-to-side anastomosis. Moreover, in ileocolostomy, such as ileocecectomy and right hemicolectomy, this procedure would not be meaningful because the ileum can easily reach the right upper quadrant of the abdomen. On the other hand, in colocolostomy, such as transversectomy, left colectomy, and sigmoidectomy, this procedure might be useful.

In TLC-IA, intra-abdominal abscess and cancer cell dissemination are a possibility. Recently, several systematic reviews and meta-analyses have demonstrated that rate of intra-abdominal abscess in TLC-IA is the same as that in LAC-EA [7,9]. In our study, although only 7 cases were included, no intra-abdominal abscess occurred. On the other hand, regarding the possibility of cancer cell dissemination, only a few studies have reported comparable long-term survival between TLC-IA and LAC-EA, with no increase in rate of intraperitoneal recurrence [18-19]. However, it is difficult to draw a conclusion based on the lack of evidence. The possibility of cancer cell dissemination is still unclear and should be assessed in the future.

This study has several limitations. First, although we demonstrated the feasibility in MBBT anastomosis, we did not show the clinical benefit of MBBT anastomosis compared with that in FEEA or overlap anastomosis. Second limitation is a feasibility, a safety and a reproducibility. This study was a small sample size including some different surgical procedures; right colectomy, transversectomy, and left colectomy. Moreover, all procedures were performed by a single



Case No	Age (Y)	Sex	BMI kg/m <sup>2</sup>	Tumor location	Extent of bowel resection	Operating time (min)	Estimated blood loss (mL)	Postoperative complications	Hospital stay (d)
1	81	M	23.7	Transverse	Transversectomy	265	10	-	17
2	65	M	21.9	Transverse	Transversectomy	290	5	Ileus	36
3	71	F	25	Transverse	Left colectomy	308	10	-	14
4	90	F	21.3	Cecum	Ileocelectomy	293	50	-	14
5	74	M	26	Descending	Left colectomy	340	50	-	12
6	34	M	21.3	Sigmoid	Sigmoidectomy	266	15	-	10
7	70	M	16.8	Transverse	Left colectomy	245	5	-	11
Mean	73.6		22.3			286	20.7		16.3

Abbreviations: BMI: Body Mass Index

**Table 1:** Patient characteristics and operative outcomes

Case No	Tumor location	Tumor size (cm)	Length of resected Specimen, (cm)	No. of retrieved lymph nodes	UICC TNM Classification*
1	Tranverse	4	17	17	II A
2	Tranverse	5	20	21	II A
3	Tranverse	2	30	8	II A
4	Cecum	3.1	23.8	7	I
5	Descending	4.5	30.5	12	II A
6	Sigmoid	5.8	21.8	25	II A
7	Tranverse	0.9	25.9	14	I
Mean		3.6	24.1	14.9	

\*UICC TNM classification was based on the 8<sup>th</sup> edition.

Abbreviation: UICC: Union for International Cancer Control

**Table 2:** Oncologic Outcomes

surgeon. Therefore, the true feasibility, safety and reproducibility is still unclear. Third limitation is cost effectiveness. The number of the usage of stapling device in MBBT anastomosis is one or two more than that in FEEA or overlap anastomosis. We have to demonstrate that MBBT anastomosis is worth the cost, comparing with other intracorporeal anastomosis. To overcome these limitations, we have to conduct a prospective clinical trial to clarify the clinical benefit and superiority of MBBT anastomosis.

## Conflicting Interest

Nothing to disclose

## Conclusion

This novel technique, which we have named MBBT, has a feasibility for end-to-end anastomosis in totally laparoscopic colectomy, ensuring a sufficient anastomotic area. MBBT could be an alternative method of intracorporeal anastomosis compared with FEEA and overlap.

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